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FIGHTING FIBERS and COMPARABLE VALUES OF FIBERS FOR USE IN COMMERCIAL FISHERIES

By Frank E. Firth*

I. Fighting Fibers

In 1941, "Manila," abaca fiber, became a Japanese prisoner. Sisal immediately came into prominence as a substitute for Manila, but competition for shipping space and risks involved in crossing the Caribbean and South Atlantic made it necessary to look for more accessible sources of this and other hard fibers.

Hemp grown in Italy and Hungary, where abundant supplies have been obtained, is now serving the Axis. The extended fighting in Russia has greatly lessened the production of the fine hemp grown there. Jute from India has been partially cut off by action in the Orient, but recent victories in that area have resulted in a steadier supply. Flax from France and Belgium, abundant export centers still is imprisoned. Shipping space and geography have thus had a great effect on our fiber supplies. Because of their importance to the military and to essential production, these fibers were early and wisely placed under the control of the War Production Board.1/

More "Manila hemp," which does not grow near Manila and is not hemp, has been used for marine cordage during the past 100 years than all other fibers combined. When the Philippines were invaded, the loss of this material was indeed serious, but the serviceability of the substitutes and blends over the last two years and the progress being made in new developments inspire confidence for the future.

Marine cordage, which is the classification used by fisheries, must meet the most exacting requirements. It must be not only tough, durable, and reliable, but must also be able to withstand the effects of constant salt-water immersion. It is the purpose of this article to explain briefly the origin and known characteristics of some of the fibers which now are commercially used or which give promise of successful application in the fisheries.2/ In general, there are two types of natural long fibers from which cordage is produced.

1. Hard or leaf fibers: These are hard and stiff and grow lengthwise through the pulpy tissues of the long leaves and the outer bark of the stems of plants found almost exclusively in the tropics. This group is used principally for cordage and coarse twine and is typified by abaca (Manila), sisal, and henequen.

2. Soft or bast fibers: These are soft and flexible, extending through the inner bark of the stems and main stalks of plants, and are used in finer twine, thread, and yarn. Commercial production of soft fibers is confined to the Temperate Zone; hemp and flax grow in the cooler regions, jute and ramie in the warmer areas. Cotton is also included in this group although these short fibers are really seed hairs.

Hemp and flax were the earliest known fibers to be utilized, originating about 3000 B.C.,

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1/ General Preference Order M-84, as amended October 27, 1943, War Production Board.

2/ Much of the information used here is from Fiber Production in the Western Hemisphere, by Lyster H. Dewey, Miscellaneous Publication No. 518, U. S. Dept. of Agriculture, Washington, D. C., 1943.

Note: This leaflet supersedes Sep. Nos. 54 and 73, reprints from Fishery Market News, January 1944 and August 1944, respectively.

flax in Central Europe and Egypt, hemp in Northern China. The Western Hemisphere contributes to the production of all the fibers, but none of the important soft fiber plants included here are native to America.

HARD FIBERS

"Agave" is a Greek word first used in 1753 to designate a genus which includes eight hard-fiber plants, the two commercially important ones being sisal (Agave sisalana) and henequen (A. fourcroydes). Thus, the term agave indicates the group, while the common names, sisal or henequen, should be used in referring to the specific fibers.

Henequen -- Henequen (Agave fourcroydes) is a hard fiber produced chiefly in Mexico, Cuba, and, to a lesser extent, in Jamaica and East Africa. Its principal market is in the United States where it is sometimes known as Mexican or Cuban sisal, but in the London market it is called simply henequen. The prepared fibers range from reddish-yellow to white in color and from 2 to 5 feet in length, depending upon the locality, soil, and care used in manufacture. Henequen is used principally as binder twine for tying sheaves of grain during the harvest. Although the demand for this purpose is extremely heavy, increasing quantities are going into marine uses while other substitute fibers are serving as binder twine. Henequen, similar to sisal but rougher, has two-thirds the strength of that fiber and about half the strength of Manila. Thus, henequen is the weakest of the hard fibers discussed here.

Sisal -- Sisal (Agave sisalana), often called African sisal, derives its name from the old seaport of Sisal in Yucatan, from which port this material was formerly shipped. Its present production is greater than that of any other hard fiber and centers chiefly in Africa, Java, and Sumatra, and to some extent in Mexico and Haiti. This plant originated in the Yucatan Peninsula where a small amount is still cultivated. In 1834, a nursery was established in southern Florida for growing the plant bulbils, but there seems to have been little effort made to develop fiber production. The market for these bulbs was world-wide, and today all cultivated sisal, outside Mexico, is traced directly or indirectly to Florida. The fibers are cream to clear white in color, range from 2 to 5 feet in length, and are more flexible and of finer texture than henequen. Sisal absorbs water but not so much as to cause serious trouble in the pulley blocks. Numerous tests, as well as practical experience on ships and in fishing, indicate that, in resistance to injurious action and salt water, the most satisfactory substitute for Manila cordage in general marine work is sisal. It averages 80 percent the strength of Manila, and by using a slightly larger size sisal rope, practically the same strength can be obtained. The principal markets for sisal are Great Britain, continental Europe, and the U. S. The fiber is commonly differentiated according to geographic origin as "African sisal," "Java sisal," etc. This fiber was formerly utilized for binder twine, but today it has achieved a high rank in the cordage field.

Abaca (Manila) -- Abaca (Musa textilis) yields the hard fiber better known as Manila or Manila hemp, which during the last 100 years has been in world-wide demand for dependable cordage. It is cultivated from the southern part of Luzon Island to the southern part of Mindanao, but does not grow well as far north as Manila (Lat. 15° N.). It has also been introduced from the Philippines into Java, Sumatra, Celebes, Borneo, and the Andaman Islands, where cultivation of the plants has produced fair quantities of abaca. Until recently, the leaf stems and trunks were stripped entirely by hand, but machines for this purpose are now coming into general use. In 1925, the U.S. Department of Agriculture successfully introduced these banana-like plants into the region around Almirante, in Western Panama. Abaca fiber produced there in this experiment has been made into rope fully equal to rope made from fibers of Philippine Island growth. This acreage has recently been increased, and some day should become an important source of abaca. A large stripping machine installed in Panama in 1942 can turn out a thousand pounds of clean, dry fibers per hour when sufficient raw material is available.

There are 16 recognized grades of abaca, based chiefly on texture, color, and cleaning method. The lengths range from 7 to 14 feet, but careful selection has produced 20-foot strands. Great Britain, Japan, and the United States have been the greatest consumers of this fiber. It is processed in 18 cordage mills in this country and in many others in Canada, Cuba, Mexico, and South America. It is used, more extensively than all other fibers combined, in marine cordage, well-drilling cables, hoisting ropes, transmission ropes, and in all coarse cordage requiring strength, durability, and reliability. Rope made from abaca fibers absorbs water very slowly and is highly resistant to injury from sea water.

Pita Floja -- Pita floja (Aechmea magdalenae), a hard fiber used locally in many parts of Latin America, is very resistant to sea water and has for many years given excellent performance in fish lines and nets, as well as in thread for sewing leather saddles, belts, etc., although it is not yet sold in the world markets. This plant, sometimes called "wild pineapple," grows abundantly from Mexico south to Ecuador. The name "Pita floja" means "thread fiber," the leaves producing light, cream white, lustrous fibers from 5 to 8 feet long. They are finer and more flexible than any of the hard fibers now in use, being stronger and more elastic than abaca (Manila), and containing 75 percent cellulose, more than is recorded for any other hard fiber. If mechanical methods of preparation should be successful, the abundant, rapid growth of the plants and the strength and durability of the fiber in sea water give promise that pita would soon be widely used in marine cordage.

Although there are other plants which furnish hard fibers, such as the Yucca lily group, they are for the most part utilized only locally. Any expansion of production will necessarily be slow because of labor shortages and inadequate transportation facilities from the areas of growth.

SOFT FIBERS

Hemp -- Hemp (Cannabis satvia), a soft fiber plant of the mulberry family, has had its name applied to numerous other long fibers, both hard and soft, but never to flax, which fiber is most nearly like hemp. Next to flax, hemp was the plant earliest cultivated for fiber production of which we have definite record, the Emperor Shen Nung having taught this art to the people of China in the 28th century B. C. Beside China, production has now spread to Japan, Iran, and Turkey, in Asia; Russia, Italy, Poland, Rumania, Hungary, Yugoslavia, and Spain, in Europe; Chile, Argentina, and the U. S., in the Western Hemisphere. Despite this widespread cultivation, Russia and Italy, prior to the war, produced more hemp fiber than the rest of the world combined.

Hemp stalks yield fibers about 6 feet long, the color varying from gray to cream white depending upon the method of retting (or rotting) the strands from the stalks. The better fibers are lustrous and have a decided snap in breaking. Hemp contains 77 percent cellulose, and because it endures heat, water and friction exceptionally well, it was used for centuries throughout the world in the manufacture of marine and other cordage requiring dependability and durability. It is still used in Europe for cordage but was largely superseded in this country by abaca about 100 years ago. There is at present considerable acreage planted to hemp in Wisconsin, Illinois, Iowa, and Indiana. Kentucky produces nearly all the hemp seeds, very little fiber being manufactured there. Machines or retting plants have been set up in each producing state by the U. S. Government on a rental basis. Soil and climatic conditions are ideal in these states, and it is expected that about 75,000 tons of fiber will be processed from the 1943 crop. The production of American hemp will undoubtedly continue into the future, long after victory.

Flax -- Flax (genus Linum) yields the highest grade soft fiber and is the oldest known fiber plant. Its cultivation has been devoted largely to the production of linseed oil from the seeds and to the production of fiber for the fabrication of fine textiles. Recently New Zealand, Canada, Peru, Mexico, and the U. S. have tended toward greater planting of this slender flower-like plant for both oil and textile purposes. The linen manufacturers use the greater part of the fiber produced. Its cellulose content of approximately 80 percent is the highest for any known fiber. Because it is exceptionally strong, light in weight, and resistant to salt-water action, flax has been widely used in our U. S. fisheries in the manufacture of gill nets; however, the present linen shortage has made necessary the employment of cotton for this purpose. Greater numbers of linen nets can be stored and handled on a small boat than is possible with heavier and weaker fibers.

Jute -- Jute (Corchorus capsularis), a member of the linden family, is a soft fiber that has been in commercial use for only about 100 years. Because of its abundance and ease of manufacture in uniform quality, it is now used more than all other vegetable fibers combined, except cotton. India produces nearly all the jute available for export. The principal use is in the manufacture of burlap and sacking, but jute is also made into rug backings and upholstery webbing. Some progress is being made in satisfying wartime demands by using jute in cordage and twine. Scientific research has developed waterproofing and anti-mildew treatments which, when applied to jute cordage made from selected fibers, have produced ropes of fair strength and durability which allowed the release of better materials

to marine users.[1] Despite these treatments, jute itself, with the lowest cellulose content among the abundant soft fibers, is too deficient in water resistance, durability, tensile strength, and elasticity to allow much use in the fisheries.

Ramie -- Ramie (Boehmeria nivea) is a soft fiber grown principally in China and Japan where it is used extensively in the manufacture of summer clothing and durable, hand-made lace. It is widely used in those two countries for making lightweight fish nets because it has high resistance to chemical action and sea water. However, because it abrades easily and lacks elasticity, despite its high cellulose content, ramie finds little use in the fisheries of other countries, and very little is exported. Steadily increasing cultivation in South America, where ramie was recently introduced, has not yet produced large scale surpluses above domestic needs. If increased quantities become available, ramie may find some applications in the North American fisheries.

Cotton -- Cotton (genus Gossypium), the soft fibers which enclose the seeds of the cotton plant, finds more diversified uses than any other fiber. Although cotton is composed almost entirely of cellulose, cordage made from it does not have the strength of the other commercial fibers mentioned because the short individual strands are only from one-half inch to two inches long. These must be spun together in a yarn and several yarns twisted into thread to utilize the strength of all the fibers. Then several threads are twisted to form twine. Lightly-twisted twine is called soft laid; tightly-twisted twine is called hard laid. The hard laid twine is more resistant to abrasion but has lower tensile strength. This fault, in spite of the superior pliability and resulting knot strength of cotton, has severely limited its use in heavy cordage where it exhibits only about half the strength of Manila.

Nevertheless, its ease of handling, adaptability to machine knitting, and abundant supply in uniform quality have led to the use of cotton twine webbing in practically every fish net in this country. Even in gill nets, cotton has taken the place of linen which is unavailable. For fish net use cotton twine, generally called seine twine, has been standardized by the various manufacturers into four types available in a large range of sizes: "soft laid" - with from 6 to 240 threads; "medium laid" - 6 to 240 threads; "hard laid" - 6 to 120 threads; "extra hard laid" - 6 to 200 threads or more.

Cotton, coming principally from our own southeastern States and in lesser amounts from Egypt, India, China, the Soviet Union, and Brazil, finds innumerable valuable applications in the wartime activities of the United Nations. Netting is an important aid in these activities whether it serves to camouflage our troops or to catch the fish which furnish food, stock feed, oil, vitamins, glycerine, and other needed products. Much effort and research are being directed toward extending the use of cotton in marine cordage through the growth and selection of stronger fibers and by the development of treatments which will make it more resistant to sea water, decay, tension, and abrasion. The success of these efforts would increase greatly the use of cotton in the fisheries.

SYNTHETIC FIBERS

Nylon -- Among the synthetic fibers recently developed for various specialized uses, nylon is outstanding. Nylon is stronger, tougher and less susceptible to water than Manila and consequently is used in the manufacture of rope for mountain troops, parachutists, and gliders. Nylon rope has been found especially resistant to abrasion when in contact with rough surfaces such as the edges of rocks and when used in pulleys and similar operations where Manila has hitherto been employed. While nylon is at present necessarily under rigid government control and restriction, its postwar users will undoubtedly include the fisheries.

1/ For further information see "Preservation and Care of Fish Nets," by Frank E. Firth and Carl B. Carlson, Fishery Market News, Vol. 5, No. 7, July 1943, also available as Fishery Leaflet No. 66 from Fish and Wildlife Service, Merchandise Mart, Chicago 54, Ill.

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II. Comparable Values of Fibers for Use in Commercial Fisheries

The commercial fishing industry was one of the first to feel the effect of the loss of imports of manila when the Japanese invaded the Philippines and East Indies. Almost immediately after war was declared, the Fish and Wildlife Service started to test those fibers which were available and might be adapted to fishing uses because there were practically no data on their comparative values as fishing cordage and twines.

The availability of fibers shifted continuously since there was no domestic production except of cotton. Uses for the latter increased at such a rate that only very small quantities of cotton rope were available for industrial uses. All other fibers had to be imported and were subject to shipping delays. In addition, the need of the Armed Forces for all types of cordage increased at a tremendous rate.

The results of the tests undertaken are summarized in the following table. Jute gave variable results depending on the use to which it was placed. This variation in performance

Comparison of Certain Cordage Fibers With Manila

Type of Fiber	Proposed Use	Approximate Tensile Strength (card)	Abrasion Resistance	Flexibility	Approximate Durability	Recommendation	Availability
		Percent			Percent		
Manila	General fisheries	100	Very good	Very good	100	Very good	None
Java sisal	General fisheries	90	Good	Very good	95	Very good	None
Blend of Java & African sisal	General fisheries	85	Good	Very good	85-90	Very good	None
African sisal	General fisheries	80	Good	Good	80	Good	Limited
Blend of African sisal with 5-10% extenders of Agavetow, Henequen, Pita or Istle fiber	General fisheries	75	Fair to Poor	Fair	60-70	Fair	Limited
Hempsal (30% American hemp and 70% African sisal)	Lobster pot warps, Lobster pot heading twine	90	Good	Very good	90	Very good	Limited
Jute cordage	Quarter ropes, haul-up lines, tackles, lobster pot warps	60	Poor	Good	50	Poor	Fairly abundant
Jute twine	Otter trawl webbing	60	Poor	Very good	30	Poor	Fairly abundant
Jute twine	Lobster pot heads	60	Fair	Very good	85-90	Good	Fairly abundant
Flax cordate	Lobster pot warps	60	Fair	Poor	75	Fair to good	Limited
Coir cordage	Lobster pot warps, Otter trawl footrope rounding	25	Poor	Poor	20	Poor	Fairly abundant
Cotton twine	Otter trawl cod-ends	55	Poor	Good	50	Fair	Limited
Cotton twine	Lobster pot heads	55	Good	Good	85	Very good	Limited
Raphia cordage	Otter trawl hanging lines	60	Poor	Fair dry Poor wet	25	Poor	Limited

is due primarily to the fact that it wears out rapidly when subjected to abrasion. Some of the secondary grades of sisal cordage were handicapped by brittleness causing ropes to part without warning and give poor performance when pulled over sheaves.

Although the tests summarized in this report were limited by the quantity available for trial, it is indicated that hempsal cordage, made up of East African sisal and domestic hemp in the proportions of 70 to 30, or 50 to 50, respectively, will be fairly dependable for general fishing purposes. Hempsal has been found second to manila and superior to straight African sisal cordage in tensile strength, abrasion resistance, flexibility, and durability. Production of this mixed fiber cordage, in the proportion of 10 percent Am. hemp and 90 percent sisal, is scheduled for the latter half of 1944 and is expected to be available to the fishing industry within a few months.

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Additional References

"Preliminary Report on Definitions and Recommended Substitutes for Vessel and Gear Cordage Items", Sep. No. 16, Fishery Market News, April Supplement 1943.

"Manila Rope Restrictions Again Tightened by M-84", Sep. No. 74, Fishery Market News, August 1944.

Note: These leaflets may be obtained from the Fish and Wildlife Service, Department of the Interior, Washington 25, D.C.